

## IN THE SPECIFICATION

Please replace the following paragraphs in the Specification with the following rewritten paragraphs:

[0002] Application Serial No. 10/650,272—/—, entitled “METHOD AND APPARATUS FOR IMPROVING CHANNEL ESTIMATE BASED ON SHORT SYNCHRONIZATION CODE,” filed on same date herewith, by Haitao Zhang, ~~attorney’s~~ ~~docket number 020306~~, which is hereby incorporated by reference herein.

[0008] To address the requirements described above, the present invention discloses a method and apparatus for estimating a communication channel impulse response  $h(t)$ . The method comprises the steps of generating a data sequence  $d_i$  having a constrained portion  $Cd_i$  associated with at least two codes  $w_0, w_1$ , wherein a correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  with one of the codes  $w_0, w_1$  is characterized by a maximum value at  $k = 0$  and less than maximum values at  $k \neq 0$ ; generating a chip sequence  $c_j$  having a chip period  $T_c$  as the data sequence  $d_i$  spread by a spreading sequence  $S_i$  of length  $N$ ; generating  $co_m(t) = co(t + mNT_c)$  for  $m = 0, 1, \dots, M$  by correlating a received signal  $r(t)$  with the spreading sequence  $S_i$ , wherein the received signal  $r(t)$  comprises the chip sequence  $c_j$  applied to the communication channel; and generating an estimated communication channel impulse response  $\hat{h}_M(t)$  as a combination of  $co_m(t)$  and  $d_m$  for  $m = 0, 1, \dots, M$ . The apparatus comprises means for generating a data sequence  $d_i$  having a constrained portion  $Cd_i$  associated with at least two codes  $w_0, w_1$ , wherein a correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  with one of the codes  $w_0, w_1$  is characterized by a maximum value at  $k = 0$  and less than maximum values at  $k \neq 0$ ; means for generating a chip sequence  $c_j$  having a chip period  $T_c$  as the data sequence  $d_i$  spread by a spreading sequence  $S_i$  of length  $N$ ; a correlator for generating  $co_m(t) = co(t + mNT_c)$  for  $m = 0, 1, \dots, M$  by correlating a received signal  $r(t)$  with the spreading sequence  $S_i$ , wherein the received signal  $r(t)$  comprises the chip sequence  $c_j$  applied to the communication channel; and an estimator for

generating an estimated communication channel impulse response  $\hat{h}_M(t)$  as a combination of  $co_m(t)$  and  $d_m$  for  $m = 0, 1, \dots, M$ .

[0027] Such systems also use the received signal to estimate the ~~input~~ impulse response of the communication channel 108. This information is used to improve later detection and reception of signals from the transmitter 110. In circumstances where the spreading sequence  $S_i$  104 is relatively short, the data packet 128 must be detected quickly, and there is less data available to estimate the response of the communication channel 108.

[0060] In one embodiment of the present invention, supercodes, such as Walsh-like supercodes, are used to drastically reduce the amount of the integration required. This technique is especially useful in systems having sufficient ~~a~~ signal-to-noise ratio (SNR).

[0061] Any ~~length-2~~ symbol length segment from this sequence can be described as either  $w_0$  or  $-w_0$ , except for a single  $w_1$  in the center. If this sequence is now correlated with  $w_1$ , the resulting correlation will be characterized by a single peak in the center and zeros elsewhere (except near the boundaries). Negatives of the two codes may be taken (e.g.  $w_0 = \{-1, -1\}$  and  $w_1 = \{-1, +1\}$ ) and/or their roles may be swapped (e.g.  $w_1 = \{+1, +1\}$  and  $w_0 = \{+1, -1\}$ ) with the same result. The three additional patterns thus obtained and their correlator patterns are listed below:

[0070] The constrained portion  $Cd_i$  602 is associated with at least two codes,  $w_0$  and  $w_1$ . The codes  $w_0$  and  $w_1$  are selected such that the correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  602 and at least one of the codes  $w_0$  and  $w_1$ , is characterized by a maximum value at  $k = 0$ , and ~~they~~ value less than the maximum value at  $k \neq 0$ .

[0071] Ideally, the correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  602 is an impulse, with  $A_{code}(k)$  equal to one at  $k = 0$ , and equal to zero at all other values for  $k$ . However, because such correlation characteristics are typically not realizable, codes  $w_0$  and  $w_1$  can be

chosen to approximate this ideal. For example, codes  $w_0$  and  $w_1$  can be chosen such that the correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  602 and at least one of the codes  $w_0$  and  $w_1$ , is such that  $A_{code}(k) = 1$  at  $k = 0$  and  $A_{code}(k) \approx 0$  for substantially all  $k \neq 0$ . Or, codes  $w_0$  and  $w_1$  can be chosen such that the correlation  $A_{code}(k)$  of the constrained portion  $Cd_i$  602 and at least one of the codes  $w_0$  and  $w_1$ , is such that  $A_{code}(k) = 0$  for  $0 < |k| \leq J$ , wherein  $J$  is selected to minimize the correlation of the constrained portion  $Cd_i$  with the one of the codes  $w_0, w_1$  for substantially all  $k \neq 0$ .

[0077] In one embodiment, the codes  $w_0$  and  $w_1$  are two symbol-long Walsh codes, and  $\hat{h}_M(t)$  is computed as  $\frac{1}{M} \sum_{m=0}^{M-1} d_m \bullet co(t + mNT_c)$ , with  $M = 2$ . In this case,  $\hat{h}_M(t)$  equals  $\hat{h}_2(t) = \frac{1}{2}(d_0 \bullet co(t) + d_1 \bullet co(t + NT_c))$ .

[0090] The foregoing has demonstrated that distortions due to this spreading sequence design can be removed from the estimate of the communications channel impulse response. Attention is now turned to the remaining distortion caused by the additive ~~noise~~ noise.  $n(t)$  121. Assuming that the noise source is white and stationary and is filtered by a receiver filter for bandwidth matching, its distortion measure can be defined as follows:

[0093] FIG. 7 through FIG. 10 are diagrams illustrating the performance improvements achieved by application of the present invention. These illustrated examples are for a case and place them, whereby a length 11 Barker code is used as the spreading sequence  $S_i$  104. FIGS. 7-10; show normalized magnitudes as a function of chip timing. No adjustments were made for group delays introduced by correlation, filtering and windowing, therefore time coordinates should be treated in the relative sense. FIGS. 7-10 also do not include the effects of additive noise.

[0094] FIG. 7 is a diagram presenting a correlator 116 output using a length 11 Barker code and conventional communication channel impulse response estimation techniques. The

correlator 116 output shows ~~to~~ a main lobe peak 702, and multiple spurious peaks 704. These spurious peaks 704 (which are 11 chips, or  $NT_c$  seconds, apart due to the length 11 Barker code) are due to the repeated transmission of the short code  $S_i$  104, which are “aliased” back upon each other. If the length of the periodic spreading sequence  $S_i$  104 were longer, there would be fewer spurious peaks 704, and the peaks 704 would not overlap the main lobe peak 702 as much as is shown in FIG. 7.